questions may be called "very easy," yet there are others quite sufficiently difficult for the ordinary public school-boy, who has a great many other things to work at besides natural science.

A boy must have read his chemistry thoughtfully, to say the least, who could answer the whole of Question 1 thoroughly. In Question 2 there is ample opportunity for showing a deeper knowledge than could be obtained by skimming over some "outlines of chemistry." So again the explanation and illustration of the peculiar oxidising and reducing properties of *nitrites*, in Question 4, and the description of the preparation and properties of the different bodies enumerated in Question 8, could, I maintain, only be given satisfactorily by boys who had acquired something more than a mere "modicum" of chemical knowledge.

It must also be borne in mind that in order to pass the Chemical Division of Group IV., a boy must take in, in addition to the chemistry of the metallic and non-metallic elements and practical analysis, either heat or magnetism and electricity.

Now although there may be reasons for combining together heat and chemistry, so long as it is understood that only the more elementary parts of heat will be required, yet it is certainly unreasonable to add on as an extra such a very comprehensive subject as that of magnetism and electricity, frictional and voltaic, including electro-magnetism.

Surely, to say the least, electrical science is quite as worthy of an independent existence as botany or geology, and I much doubt whether many would hesitate in admitting it to be much harder than either.

My own opinion is in favour of Mr. Wilson's suggestion—to divide Group IV. into Pass subjects and Honour subjects, requiring only an elementary knowledge of theoretical chemistry, and perhaps the simpler parts of heat for the one, while practical analysis with higher knowledge of heat, *or* electricity and magnetism, might be required from those who aimed at taking honours in science.

It is perhaps due to the school to say that we can hardly be supposed to be frightened at the prospect of these examinations. Last July three in the Sixth took in chemistry as a certificate subject: all passed and two obtained "distinction"—three being the total number who obtained such distinction out of the twenty-eight candidates who presented themselves for examination in this subject. T. N. HUTCHINSON

Rugby

In my letter last week, p. 329, I said that the papers set in science in the certificate examination *last year* were very easy. This was a slip. I was absent from England when they were set, and had never seen them. I had in my mind the papers of the year before.

The papers of last year were quite hard enough. It must be remembered that very many schools give only *two lessons a week* to science. JAMES M. WILSON

ANNIVERSARY ADDRESS OF THE PRESIDENT OF THE ROYAL GEOLOGICAL SOCIETY, JOHN EVANS, F.R.S.

MR. EVANS began by referring to the immense advances in geological science since 1825, when the Society received its charter, and pointed out that although there now existed a considerable body of professional or trained geologists, yet amateurs need not be discouraged from taking up the science which now embraces so wide a field that there is ample room for both. He then referred to the prosperity of the Society, to its publication, its medals, and other means for fostering the science, and to its valuable museum, an "interesting notice of which," he intimated, "appeared in NATURE, vol. xiii. p. 227." Mr. Evans then spoke of the present prospects of the science, of the bearing which recent discoveries in other branches of knowledge has upon it, and of the direction in which future discoveries are likely to be made. In this connection he referred to the recent researches in solar physics by means of spectrum analysis and solar photography, as having a close and intimate bearing on the early history of the earth, and which was discussed by Prof. Prestwich in his inaugural lecture at Oxford (NATURE, vol. xi. p. 290). He spoke also of the importance of spectrum analysis to the metallurgist, referring to the researches of Mr. W. C. Roberts in quantitative analyses of gold-copper alloys. Mr. Evans then spoke at some length of the important results already attained by the *Challenger* Expedition as to the nature of the sea-bottom. In speaking of the Arctic Expedition, from which geology hopes to gain much, he referred to the powerful evidence which exists in the fossil flora of Greenland and Spitzbergen, of the prevalence in the Arctic regions at one period of a distinctly warm climate.

Mr. Evans then went on to say:—The three points which it appears to me are most important to bear in mind with regard to the Arctic flora are:—1, That for vegetation such as has been described, there must, according to all analogy, have been a greater aggregate amount of summer heat supplied than is now due to such high latitudes; 2, that there must have been a far less degree of winter cold than is in any way compatible with the position on the globe; and 3, that in all probability the amount and distribution of light which at present prevail within the Arctic circle are not such as would suffice for the life of the trees.

Should the present Arctic expedition succeed in finding traces of what must be regarded as a temperate, if not indeed a sub-tropical fossil flora, like that of Greenland, and Spitzbergen, extending to latitudes still nearer the pole, it does appear to me that geologists will be compelled to accept as a fact that the position of the axis of rotation of our planet has not been permanent; and they will have to call upon astronomers to find some means of admitting what they now regard as impossible.

An astronomer and mathematician of no mean ability, the late Sir John W. Lubbock, in a paper communicated to this Society in 1848, has speculated upon this subject, which was in consequence discussed by the late Sir Henry Delabeche in his Presidential Address in 1849.

Sir John Lubbock remarked that the dictum of Laplace as to the impossibility of accounting for the changes which have taken place on the surface of the earth, and in the relative positions of land and water, by a change in the position of the axis of rotation, was founded upon the absence of two considerations, both of which appeared to him essential. These were—

1. The dislocation of strata by cooling,
2. The friction of the surface.

The latter consideration is apparently of but little importance; but with regard to the former, he pointed out how, if from any cause the axis of rotation did not coincide with the axis of figure, the pole of the axis of rotation would describe a spiral round the pole of the axis of figure until it finally became, as it is at present, identical with it. He considered it unlikely that originally the axis of rotation should have coincided exactly with the axis of figure, unless the whole globe were perfectly fluid; but added that we might go back to a time less remote, when the earth was in a semifluid state, and in consequence of the different degrees of fusibility of different substances, was partly solid, in irregular masses, and the two axes did not, in consequence, coincide. We might, he added, assume the original state of want of uniformity between them to have been at a period even more recent, when the earth consisted of land and water, and was suited for the support of animal life. He then proceeds to show how, if, after any length of time the solid spheroidal part of the earth moved about any new axis of rotation, the water would occupy a new position about a new equator, land would become sea, and sea land, &c.

He adds that if the axis of the earth would suffer a displacement by reason of the causes which produce the precession of the equinoxes, we should have another and more natural way of accounting for the existing phenomena; but this has been held to be impossible.

I am not at present going to question whether this holding is correct; but with regard to Sir J. W. Lubbock's reasoning as to the necessity of the axis of figure coinciding with that of rotation, it appears to me of the greatest importance; for if it hold good, any alteration in figure cannot but have some effect on the position of the axis of rotation. No doubt, if the whole globe, or even the solid portion of it, were a regular spheroid, with a large

equatorial protuberance, any modification on its surface would have to be on an enormous scale to produce any sensible effect upon its axis of revolution. But, after all, is the earth, strictly speaking, a spheroid?—and are not some of the arguments and dicta based upon its spheroidal character founded on a fallacy? For it does appear to me a fallacy to treat as one homogeneous spheroid, a body partly consisting of a mass of solid or quasi-solid matter of irregular form, and partly of a liquid mass in constant motion, irregularly distributed over a portion of its surface. No doubt the contour of the liquid portion is, according to established geometrical laws, almost that of a regular spheroid; but its distribution, except in the case of inland seas, can have but little to do with the regulation of the movement of the solid body on which it rests. It is true that Laplace has maintained that "whatever may be the law of the depth of the ocean, and whatever the figure of the spheroid which it covers, the phenomena of precession and nutation will be the same as if the ocean formed a solid mass with this spheroid;" but do the position of the axis of revolution and its permanence in one spot come under the same category as precession and nutation? It certainly appears to me that the position of the axis of revolution must mainly depend upon the form of the mineral portion of the globe, and be but in the slightest degree affected by the distribution of the ocean, the specific gravity of which is moreover only about one-fifth of that of the more solid portion.

With regard to the permanence of the axis of rotation, if it must of necessity coincide with the axis of figure, and if the figure of the mineral portion of the earth, in consequence of upheavals and depressions, of the wearing away of continents and the transportation of their constituents by mechanical or even chemical means, is being constantly changed, so as to acquire a new axis, then the axis of rotation must also as constantly be undergoing a change of position.

Let us now glance at some of the irregularities of form of the more solid part of the globe as at present existing. The difference between the polar and equatorial diameters of our globe has been calculated at about 26 miles, or about 13 miles in the radius; but at the equator itself, little more than one-fifth of the circumference of the globe is dry land, and nearly four-fifths are sea; and this sea is by no means shallow, as the soundings taken by the "Tuscarora," the "Challenger," and other exploring vessels will prove. Leaving those taken near land out of the calculation, I find that 48 soundings in the Pacific, between 15° and 30° north latitude, give an average depth of 2,634 fathoms, or 5,268 yards, that is to say, within a few yards of three miles. The South Pacific does not appear to have been so well explored; but across the Atlantic, in the equatorial regions between 10° N. and 10° S., I find that an average of 32 soundings gives a mean depth of 2,309 fathoms, or 4,618 yards, while, in one spot in lat. 15° S., Sir James Ross did not find the bottom with a line of 4,600 fathoms, or nearly 5¼ miles. In the Indian Ocean, within the same limits, 20 soundings give an average of 2,468 fathoms, or 4,936 yards, or more than 2¾ miles. Taking these soundings as fair representations of the depth of the sea in the neighbourhood of the equator, it appears that we may at once reduce the equatorial diameter of the more solid part of the globe by from 5½ to 6 miles over nearly four-fifths of its circumference; that is to say, we may reduce the usually accepted equatorial protuberance from about 13 miles to a little over 10. It is not within my province to inquire whether the fact of so large a portion of the equatorial protuberance being of so much less specific gravity than if it were composed of mineral matter, will in any way affect the established calculations with regard to the precession of the equinoxes and the nutation of the poles, or, what is of more importance to us, the inferences with regard to the crust of the earth which have been thence deduced.

But while so large a portion of the surface of the land is, in the equatorial regions, so much below the normal level, there are, especially in the northern hemisphere, large tracts of land which, like the great plateau of Tibet, are some thousands of feet above it. The average elevation of the whole of Asia has, indeed, been estimated at 377 yards, or nearly a quarter of a mile above the sea-level. The depth of the ocean in non-equatorial regions must no doubt be taken into account; but practically, the spheroidicity of the globe, on which the stability of the pole has been held to depend, may be regarded as, even at the present time, considerably less than is usually supposed. When, however, we come to think of the enormous elevations and depressions which some parts of the globe have undergone during geological time, it is by no means difficult to imagine conditions under which the general average, so to speak, of the surface, would approach much more nearly to the form of a sphere, and the globe would become much more sensitive of any disturbances of its equilibrium; but whether the globe is a sphere or a spheroid, it is hard to see why disturbances of its equilibrium should not affect the position of its axis of rotation.

Taking our globe with the distribution of land and water as at present existing, I should like to inquire of mathematicians what would be the theoretical result of such a slight modification, geologically speaking, as the following:—Assume an elevation to the extent, on an average, of 4,000 feet over the northern part of Africa, the centre of the elevation being, say, in 20° north latitude. Assume that this elevation forms only a portion of a belt around the whole globe, inclined to the equator at an angle of 20°, and having its most northerly point in the longitude of Greenwich, and cutting the equator at 90° of east and west longitude. Assume that along this belt the sea-bottom and what little land besides Africa it would traverse were raised 4,000 feet above its present level over a tract 20° in width. Assume further that the elevation of this belt was accompanied by corresponding depressions on either side of it, so as to leave the total volume of the mineral portion of the earth unaffected. Would not such a modification of form bring the axis of figure about 15° or 20° south of the present, and on the meridian of Greenwich, that is to say, midway between Greenland and Spitzbergen? and would not, eventually, the axis of rotation correspond in position with the axis of the figure?

If the answer to these questions is in the affirmative, then I think it must be conceded that even minor elevations within the tropics would produce effects corresponding to their magnitude; and also that it is unsafe to assume that the geographical position of the poles has been persistent throughout all geological time.

It is not the first time that I have insisted upon this point; for, some ten years ago, I pointed out another possible means of accounting for a change in the geographical position of the axis of the earth. My hypothesis was, however, founded on the assumption of the globe consisting of a comparatively thin crust, with an internal fluid nucleus over which the crust would slide when, from any geological cause, its equilibrium was disturbed. To this it has been objected[1]—1st, That there would be a tendency in the transfer of sediment from one part of the globe to another, and in the various elevations and depressions of land simultaneously, to balance each other; and 2nd, that the friction over the nucleus would be too great, and that, owing to the earth being a spheroid and not a perfect sphere, any motion of the crust would be attended by great resistance, and the bending and rending of its mass.

To these objections it may be replied that the effects of the transfer of sediment from one place to another, and of elevations and depressions of land going on at the same time, are just as likely to be doubled by the depressions taking place in the same hemisphere as the elevations, but on opposite sides of the pole, as they are to neutralise each other; and, 2ndly, that with a comparatively thin crust, the readjustment to a fresh position on a nucleus so slightly spheroidal as that supposed to exist in the earth, is not accompanied by any great change of form, or certainly not more than what the contorted rocks all over the world have undergone.

I am not, however, on the present occasion, going to attempt to prove that the assumption involved in my hypothesis is reasonable. How we are to account for all the vast oscillations of the earth's surface, which we find to have been going on ever since the earliest geological period up to the present day, on any assumption more reasonable, I will leave for others to determine. I have already called attention to the bearing which recent researches in solar physics have upon this subject, and I am content to leave the matter as it stands, in the hope that before many years have passed, we may learn more either in its proof or disproof.

The moral which I wish to draw from all that I have just said is this:—That so long as there is a possibility, not to say a probability, of the geographical position of the poles having changed, it is premature to invoke intense glacial periods to account for all the glacial phenomena which may be observed. Much as we must esteem the labours of M. Adhémar and Mr. Croll, and others who have gone so deeply into the question of glaciation—enormous as have been the effects of ice in this and other countries—there are many who cannot but feel that the ice-caps invoked almost transcend our powers of belief, and who will be grateful to any astronomer or mathematician who will bring the pole

[1] Lyell's "Principles," 11th edition, vol. ii. p. 209.

round which they were generated, somewhat nearer to our doors.

There is yet one point on which, before quitting the subject, I may add a few words. Sir J. W. Lubbock, in the paper from which I have already quoted so much, has hinted at the possibility of some want of homogeneity in the constitution of the globe, so that in cooling, the position of the axis of rotation may have changed. The varying amount of subterranean heat and volcanic energy in the same region at different periods of the earth's existence has frequently been commented on, as has also the varying degree of subsidence or elevation in the same tract at different times. The forces, whatever they may be, to which these upward and downward movements are due, have, as Sir Charles Lyell has remarked, "shifted their points of chief development from one region to another, like the volcano and the earthquake, and are all, in fact, the results of the same internal operations to which heat, electricity, magnetism, and chemical affinity give rise."

Whether changes in the specific gravity of enormous masses of rock in consequence of their being heated would be of sufficient degree to disturb the equilibrium of the globe, is a difficult question; but the remarkable position of the magnetic poles of verticity with regard to the actual poles of the earth, and the distribution of the magnetic force over the earth's surface may, as has been suggested to me by Capt. F. J. Evans, F.R.S., have some geological significance. These poles are in lat. 70° N., long. 96¾° W., and in lat. 73½° S., long. 147½° E. If we draw a circle around the globe, cutting these two points, we find that the magnetic poles, instead of being 180° apart, are only about 165° distant in one direction, while they are about 195° in the other. In like manner the magnetic equator, or line of no dip, differs considerably in position from the terrestrial equator, being drawn about 15° to the south over South America, and about 10° to the north over Africa, and in passing the great Asiatic continent. There is also this singular circumstance, which was insisted upon by Sir Edward Sabine nearly forty years ago—viz., that if the globe be divided into an eastern and a western hemisphere by a plane coinciding with the meridian of 100° and 280°, the western hemisphere, or that comprising the Americas and the Pacific Ocean, has a much higher magnetic intensity distributed generally over its surface, than the eastern hemisphere, containing Europe and Africa and the adjacent part of the Atlantic Ocean. The points of the greatest intensity of the magnetic force, moreover, do not correspond with the magnetic poles, as there are two such foci in the northern hemisphere (those of America and Siberia) making it probable that there are two also in the southern hemisphere.

Such facts would seem more in accordance with a want of uniformity in the inner constitution of the globe than with its being a body all the parts of which are arranged in perfect symmetry. Some abnormal features in the direction of gravity in different parts of the world seem also to afford corroborative evidence to the same effect. The subject is one of perhaps too theoretical a character for the geologist to approach; but if any definite connection could be established between terrestrial magnetism and the internal constitution of the globe, we might, possibly, be justified in drawing the inference from its phenomena, that there are forces in operation in the interior of the earth by which its equilibrium may have been disturbed, and its axis of revolution thus caused to change in position.

(*To be continued.*)

NOTES

THE Italian naturalist Beccari is again in New Guinea, exploring the north coast near Humboldt's Bay, along with an expedition sent out by the Governor-General of the Dutch Colonies. Of his former companion, D'Albertis, now at Yule Island, near the south-eastern extremity of New Guinea, we regret to hear that one of his collections from that district, containing about 35,000 insects and 700 reptiles, has been lost on its transit from Cape York. The bird-skins were, fortunately, not sent by the same vessel, and are therefore safe.

THE Paris Observatory has received for January last Meteorological observations made six times each day, at the Norma Schools, at the following thirty-four places:—Albertville, Alençon, Amiens, Aurillac, Avignon, Beauvais, Besançon, Bourg, Bourges, Caen, Carcassonne, Chalons, Chartres, Chaumont, Clermont, Commercy, Dragnignan, Foix, Grenoble, Le Mans, Le Puy, Loches, Lons-le-Saulnier, Mâcon, Melun, Mirecourt, Nimes, Orléans, Parthenay, Périgneux, Privas, Rouen, Troyes, and Villefranche. The importance of this valuable system of observation in its bearings on the peculiarly difficult problem of the meteorology of France, it would be difficult to over-estimate, especially when taken in connection with the numerous observers of thunder-storms and other phenomena requiring few or no instruments for their observation, whose services are being secured in different departments.

PROF. CANTONI has intimated to the Permanent Committee appointed by the Meteorological Congress of Vienna that the Italian Government has been pleased to intimate its readiness to invite the countries which were represented at Vienna to attend a Meteorological Congress in Italy in the autumn of 1877.

THE Permanent Committee of the Vienna Meteorological Congress have announced their intention to hold their next meeting in London, in Easter week, commencing April 18 next.

NINE Lectures on the Shoulder-Girdle and Fore Limb of Vertebrata, will be delivered in the Theatre of the Royal College of Surgeons, on Mondays, Wednesdays, and Fridays, at 4 P.M., commencing on Monday, March 6, 1876, by Professor W. K. Parker, F.R.S.—Lecture I. March 6. The Vertebrate Skeleton. II. March 8. Shoulder-girdle and Fore Limb of Fishes. III. March 10. Shoulder-girdle and Fore Limb of Fishes. IV. March 13. Shoulder-girdle, Fore Limb, and Sternum of Amphibia. V. March 15. Shoulder-girdle, Fore Limb, and Sternum of Reptiles. VI. March 17. Shoulder-girdle, Fore Limb, and Sternum of Birds. VII. March 20. Shoulder-girdle, Fore Limb, and Sternum of Mammals. VIII. March 22. Shoulder-girdle, Fore Limb, and Sternum of Mammals. IX. March 24. Summary and conclusion.

THE following is the business to be brought before the Half-Yearly General Meeting of the Scottish Meteorological Society to-day:—1, Report from the Council of the Society; 2, Report from the Ozone Committee; 3, The Salmon, Grilse, and Trout Fishings of the Tweed, in relation to Meteorology, by G. L. Paulin, Esq., and the Secretary; 4, Report from the Herring Committee.

THE following memoirs and reports of the United States Geological and Geographical Survey of the Territories, under the direction of Prof. Hayden, are now in the press, and will be issued during 1876:—1. Monograph of the Rodentia of North America, by Elliott Coues and J. A. Allen. Quarto, about 500 pages, with numerous illustrations. 2. Monograph of the Geometrid Moths, by Dr. A. S. Packard, jun. 350 pages quarto, with 13 plates. 3. The Fossil Invertebrata of the Western Territories, by J. B. Meek. 600 pages quarto, and 45 plates, with numerous woodcuts in text. 4. The Fossil Flora of the Lignitic group of the Western Territories, by Leo Lesquereux. 65 plates, quarto. 5. The Ethnography and Philology of the Hidatsa Indians (Minnetarees of the Upper Missouri). 400 pages, octavo. 6. Annual Reports of the Survey for 1874 and 1875. 7. Bulletin of the Survey for the year 1876; several important articles in press. Other works are in process of preparation, and may be printed before the close of the year.

THE *Bulletin* of the United States Geological and Geographical Survey of the Territories, Prof. Hayden in charge, has just issued Nos. 5 and 6, which close the year 1875. In No. 5, there are nine articles on various subjects of Geology and Natural History. In No. 6 there are four articles, with table of contents and complete index. It is suggested by Prof. Hayden that the two *Bulletins* of 1874 be bound with those of 1875, as Volume I. The index and title-page have been made with this idea in view. Volume I. will then comprise about 600 closely printed 8vo. pages, with 26 plates, sections, &c.